REMARKS

Review and reconsideration of the Office Action of September 7, 2005 is respectfully requested in view of the above amendments and the following remarks.

Claim 21 is amended to recite particle size range limitations for the small and large particles, for which support can be found in paragraphs [00035] and [00036] of the specification.

Very basically, the present invention provides a mold produced by rapid prototyping for the metal casting art, which mold simultaneously solves a number of problems.

The molds should produce metal castings not subject to warping and deformation as found in the state of the art.

The molds must have good dimensional stability in the green form (thus overcoming need to be fired). That is, although mold solidification by sintering is known, sintering results in shrinkage, and shrinkage is difficult to pre-calculate, so that the final dimensions of a precision casting may not be as desired. According to paragraph [00018] of the specification, no significant sintering shrinkage should occur at temperatures below the casting temperature.

Third, the molds must provide good surface quality (less steps and graininess).

These objectives are accomplished by providing a mold in which, according to paragraph [00013] of the specification, the casting mold has a high thermal coefficient of expansion, so that the difference between the thermal coefficient of expansion between the cast metal and casting mold is kept small (preventing thermal tensions, warped castings, broken molds, etc).

Further, the content of binder phases is reduced, which is accomplished by requiring the use in combination of fine particle size and coated coarse particle size sinterable ceramic fine particles, and controlling a number of parameters not previously recognized to be result-effecting.

The present invention thereby solves a problem which has long plagued the rapid prototyping metal foundry art.

On review of the Final Office Action Applicants note that the Naito reference cited by the Examiner not only does not address the problem to be solved by the present invention, but it appears the Examiner may have relied on some parts of Naito as teaching something that is

actually not relevant to the present invention. Naito in fact says nothing about **thermal coefficient of expansion** but only the opposite – **linear thermal contraction** (see the description to Table 10 at column 22, line 6 "... the linear contraction (%) at 1000°C was measured ...", so Naito measured the usual volume reduction by firing or "shrinkage") – obviously measuring **shrinkage** occurring during firing – something not related to the phenomenon underlying the present invention wherein two particle sizes of ceramic powder are used to produce a mold having a thermal coefficient of expansion matched to that of metal, and no significant shrinkage prior to casting.

Applicants further point out that Naito measured linear thermal contraction "... on test pieces having a diameter of 10 mm ..." (see the description to Table 10 at column 22, line 3). Those test pieces were (instead of pure one component fine particles as in rapid prototyping) composites of a magnesia type board aggregate and a binder and water and hardening agent (see the description to Table 10 at column 20, line 40 to column 21 line 28). Naito thus concerns foundry bricks, and has measured nothing (i.e. especially NO thermal expansion) on ceramic fine particles.

Finally, the Examiner may be overlooking two very significant claim limitations, namely,

- "for metal foundry or casting of fine metal parts" and
- "produced by a generative rapid prototyping process".

Naito does not concern an environment in which a metal is form-fittingly in contact with a ceramic. Naito is not concerned with a mold for metal casting, does not suffer the problems when a metal cast into a mold is in an expanded state and shrinks as the metal mold first expands then shrinks. Naito thus is not concerned with matching the thermal coefficient of the mold to that of a metal.

Claim 21 has been amended to reflect that the present invention is concerned with the behavior of particles in the nano- or micrometer range, while the prior art is concerned with particles in the millimeter range.

That is, both the fine and the coarse particles used in the present invention are used in rapid prototyping, a technique in which a layer of very fine particles is deposited (to form a relatively loose layer thereof having a typical thickness of about 100-200 microns – see US

Patent 5, 204,055 referenced in paragraph [0005] of the present specification, as well as US Patent 6,109,332 referenced in paragraph [0006] of the present specification teaching that the preferred particle size for rapid prototyping should be 100-200 microns).

Office Action

Turning now to the Office Action, the paragraphing of the Examiner is adopted.

Claims Rejections – 35 USC § 103

The Examiner first repeats the rejections of record:

Claims 21-22, 25-27, 30-33 and 39 are rejected under 35 U.S.C. 103(a) as being obvious over Langer et al. in view of Naito et al.

Claims 23-244, 34-35 and 40 are rejected under 35 U.S.C. 103(a) as being obvious over Langer et al. in view of Naito et al.

Claims 28-29 are rejected under 35 U.S.C. 103(a) as being obvious over Langer et al. in view of Naito et al. and further in view of Kington.

Claims 36-38 are rejected under 35 U.S.C. 103(a) as being obvious over Frank et al. in view of Naito et al.

The position of the Examiner can be found on pages 2-5 of the Office Action.

Response to Arguments

Then, the Examiner stats his present position. The Examiner indicates that Applicant's arguments filed 6/27/05 have been fully considered but are not persuasive.

The position of the Examiner can be found on page 5 of the Office Action.

Applicants respectfully traverse.

The references cited by the Examiner do not concern either the problem or the solution underlying by the present invention.

Naito does not relate to the rapid prototyping process of mold making, the process to which the present process claims and product-by-process claims are limited.

First: The coarse particles of Naito (size 1-5 mm) are far too coarse for the use in RP methods were standard sizes vary between 100 and a maximum of 300 μm. The US Patents (5, 204,055 and 6,109,332) cited in the present specification as exemplifying state of the art rapid prototyping, teaching that the particle size for rapid prototyping should be 100-200 microns.

Second and most important: Naito says nothing about thermal expansion, but only about the opposite: linear thermal contraction (see the description to Table 10 at column 22, line 6 "... the linear contraction (%) at 1000°C was measured ..."). So Naito measured the usual volume reduction by firing or "shrinkage" which is only one of the factors overcome by the present invention.

Third: Naito measured nothing (i.e. especially NO thermal expansion) on ceramic fine particles. Instead he measured linear thermal contraction "... on test pieces having a diameter of 10 mm ..." (Compare the description to Table 10 at column 22, line 3). Those test pieces were (instead of pure one component fine particles as in the present invention) composites of a magnesia type board aggregate and a binder and water and hardening agent (Compare the description to Table 10 at column 20, line 40 to column 21 line 28).

The present invention, in contrast to the teaching of Naito, addresses the problem of the poor quality of metal parts made using molds made by a rapid prototyping process. The invention provides molds which have good dimensional stability in the green form (thus need not be fired), provide good surface quality (less steps and graininess) and, most importantly, produce metal castings not subject to warping and deformation as found in the state of the art.

Naito et al concerns refractory lining materials, not mold materials. These materials are disclosed as having <u>low</u> thermal coefficient of expansion (TCE) (desirable for lining a furnace), thus have no relevancy to the present invention wherein the thermal coefficient of expansion of

the mold is high and thus substantially compatible with metals having high thermal coefficient of expansion.

In the present invention all the above discussed problems endemic to state of the art rapid prototyping molds for metal foundry are overcome by use of a ceramic comprised of

- coated ceramic coarse particles and
- sinterable ceramic fine particles wherein the sintering temperature of the fine particles is at least 50°C below that of the coarse particles.

This combination provides

- high surface quality
- improved dimensional trueness of cast metal part due to better matching of mold TCT to metal TCE,
- substantially no sintering shrinkage, and
- sufficient strength to be used for foundry casting in the green state.

Naito et al, in contrast, concerns unfired refractory bricks (bricks which need not be pre-fired prior to use, but are sufficiently stable prior to firing, and become fired during use in a furnace).

The problem with prior art unfired refractory bricks is that when fired, the area nearest the flame may become sintered, the area of the brick furthest from the flame may not be sintered but maintains strength due to remaining binders, but in an intermediate zone the brick is not fired but looses binder, thus is weak and liable to crack.

Naito et al solve the problem by use of a special three-binder mixture, whereby the weak zone of partially fired bricks is overcome.

This has nothing to do with the present invention.

As disclosed at Naito et al. col. 31, lines 62 on:

On the other hand, when the siliceous binder, organic binder and phosphate type hardening agent are incorporated in amounts satisfying the requirement of the

present invention, ... **<u>the thermal linear expansion or contraction was very small</u>**.

Further, Naito et al does not concern metal casting molds made by 3D printing.

Finally, on close reading of Naito et al, applicants note that this reference teaches

1-20 parts by weight siliceous binder (silicic acid)

2-15 parts by weight organic binder

0.5 to 20 parts by weight phosphate type <u>hardening agent</u>

100 parts by weight refractory aggregate.

The above siliceous binder is discussed in terms of "pot life" implying a solution (col. 5 line 42), is referred to as a solution (col. 5 line 41), and measured as 5-50% solids concentration in water. Thus, siliceous binder is in the form of a solution, not in the form of particles. The composition of Naito et al, in addition to being low TCE, is not relevant to the present composition.

Withdrawal of the rejection is respectfully requested.

Applicants respectfully submit that, since Naito does not suggest the subject matter of the main claims, the secondary references can not provide suggestion for dependent claims properly depending from allowable main claims.

Withdrawal of the rejection is respectfully requested.

Respectfully submitted,

Date: **February 7, 2006**

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CERTIFICATE OF MAILING AND AUTHORIZATION TO CHARGE

I hereby certify that the foregoing AMENDMENT B for U.S. Application No. 10/826,582 filed April 16, 2004, is being deposited in via facsimile to 571.273.8300, United States Patent and Trademark Office on **February 7, 2006**.

The Commissioner is hereby authorized to charge any additional fees which may be required at any time during the prosecution of this application without specific authorization, or credit any overpayment, to Deposit Account No. 50-0951.

Valee Bartels

Valee Bartels